AD_____

Award Number: DAMD17-02-1-0523

TITLE: Comparison of Image Quality Among Variations in Specimen Tissue Compression and Fluid Immersion for Diffraction Enhanced Imaging

PRINCIPAL INVESTIGATOR: Christopher A. Parham

CONTRACTING ORGANIZATION: University of North Carolina
Chapel Hill, North Carolina 27599-1350

REPORT DATE: January 2005

TYPE OF REPORT: Annual Summary

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2005	Annual Summary (1 Jun 2002 - 31 Dec 2004)

4. TITLE AND SUBTITLE
Comparison of Image Quality Among Variations in Specimen Tissue Compression and Fluid Immersion for Diffraction Enhanced Imaging

5. FUNDING NUMBERS
DAMD17-02-1-0523

6. AUTHOR(S)
Christopher A. Parham

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of North Carolina
Chapel Hill, North Carolina 27599-1350

E-Mail: christopher_parham@med.unc.edu

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 Words)

Purpose: The current standard for breast cancer screening and diagnosis is screen-film mammography, which utilizes the principle of x-ray absorption to derive image contrast. A new imaging modality called Diffraction Enhanced Imaging (DEI) builds upon conventional x-ray imaging by adding two additional contrast mechanisms of refraction and scatter. Applications of this technique to breast imaging are promising, demonstrating significant improvements in visualization when compared digital mammography. One of the primary reasons for compressing the breast is to reduce the deleterious effects of x-ray scatter, reducing the total path through which the photon travels. This study seeks to investigate the effects of compression on breast tissue visualization using DEI. Results from this study will be applied to the development of a clinically based DEI system.
Materials and Methods: Four tissues were imaged at different levels of compression using conventional mammography and DEI. A reader study will be used to determine the effect of compression on visualization
Results: Pending
Conclusion: Pending

14. SUBJECT TERMS
Breast imaging, x-ray imaging, mammography, diffraction enhanced imaging

15. NUMBER OF PAGES
14

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Table of Contents

INTRODUCTION:

The current standard for breast cancer screening and diagnosis is screen-film mammography, which utilizes the principle of x-ray absorption to derive image contrast. A new imaging modality called Diffraction Enhanced Imaging (DEI) builds upon conventional x-ray imaging by adding two additional contrast mechanisms. The addition of a silicon analyzer crystal in the path of the x-ray beam facilitates the generation of refraction and scatter contrast. In addition, the analyzer crystal is a superb angular filter and virtually eliminates the effects of unwanted x-ray scatter. Applications of this technique to breast imaging were promising, demonstrating significant improvements in visualization when compared digital mammography. One of the primary reasons for compressing the breast is to reduce the deleterious effects of x-ray scatter, reducing the total path through which the photon travels. This study seeks to investigate the effects of compression on breast tissue visualization using DEI. Results from this study will be applied to the development of a clinically based DEI system.

BODY:

In conventional mammography, image contrast is based on x-ray absorption, which facilitates visualization of tumors or changes in tissue. A limitation of x-ray absorption based imaging is that differences between healthy and cancerous tissues are very small and scattering of x-rays can lead to blurring and lower contrast, making it difficult to detect small tumors. These small tumors, if missed, will continue to grow until such time that their size and density is sufficient for visualization. Given the fact that cancer is a time dependent disease, detecting malignant areas at an early stage is paramount. Malignant areas of tissues may have similar densities, which will not produce a great deal of contrast. Diffraction Enhanced Imaging (DEI) utilizes a silicon analyzer crystal in the path of the x-ray beam, which generates the additional contrast mechanisms of refraction and ultra-small angle scatter. DEI is based on Bragg's law of x-ray diffraction, making the analyzer crystal an angular filter with a resolution on the order of tenths of microradians. The addition of refraction and ultra-small angle scatter contrast may allow for visualization of critical structures in breast tissue that may have minimal absorption contrast. Previous studies investigating breast tissue and DEI have shown significant improvements when compared to digital mammography [1].

The overall goal of the DEI Development Group is to build a clinical imaging prototype, but the system is currently in a laboratory form at the National Synchrotron Light Source, Brookhaven National Laboratory[2].

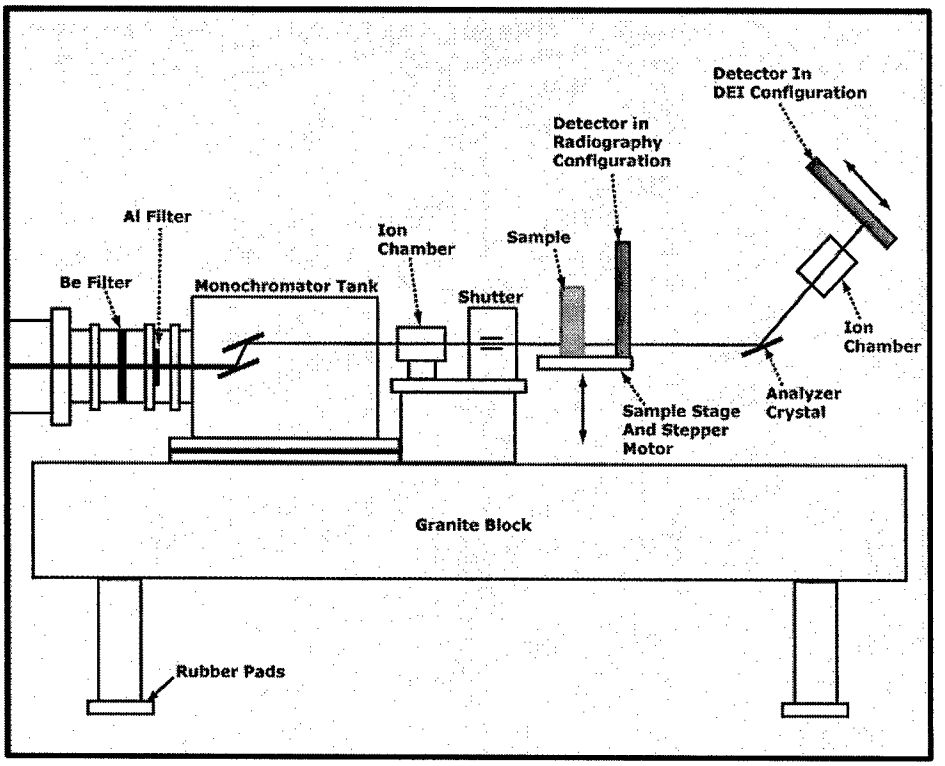

Figure 1: NSLS X-15A Experimental Setup

As currently implemented, the DEI method uses single-energy (monochromatic) x-rays instead of the broad polychromatic energy beam of conventional imaging. The object or tissue is scanned through the beam and the data is recorded on a detector.

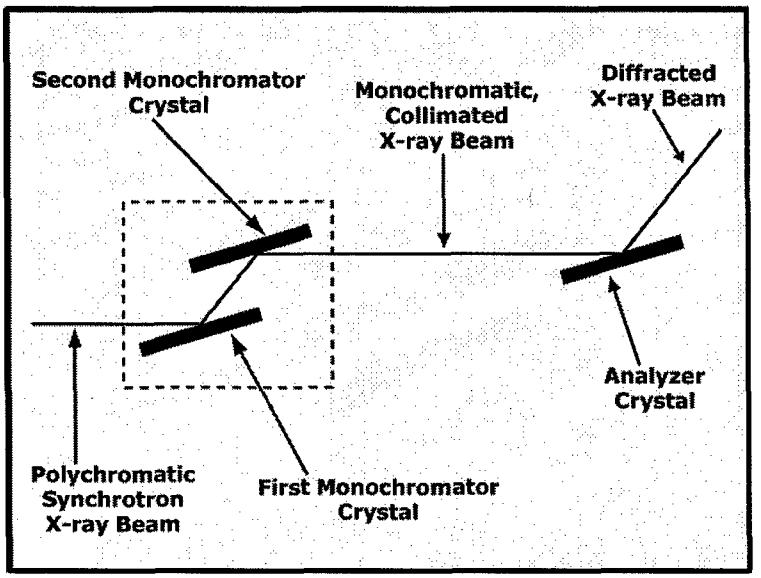

Figure 2: Passage of x-ray beam through the monochromator and analyzer crystal

In contrast to conventional x-ray systems, the DEI system utilizes a perfect silicon crystal to collimate the x-ray photons as they leave the object being imaged. Why is this important? Photons can do several things when they interact with matter, and one of the most common events is scatter. The more photons scatter, the more the image will be blurred. To counteract this effect breast tissue is compressed for a typical mammogram, thus reducing the change that the photons will scatter. The level of compression needed results in a considerable level of discomfort and pain for patients. The hypothesis set forth in this proposal is that the components of a DEI imaging system will reduce or eliminate the need for breast compression. It is believed that the filtering effect of the silicon analyzer crystal will be far more effective than mechanical compression of the breast.

Overview of Research Progress:

Task 1:

a) Task 1 involved the selection of mastectomy and surgical pathology specimens for use in the study. As stated in the proposal, four specimens were to be selected: one normal, two samples containing calcifications, and one sample containing a cancerous mass. Several samples were selected for imaging, and four high quality samples were selected for use in the study. This process was initiated in the first year of the grant and is now complete.

Task 2:

a) An immobilization specimen container was built and developed during the first year of the grant and is now complete.

b) The uncompressed specimens were imaged using a General Electric digital mammography system at UNC hospitals and the specific regions of interest were identified by an expert radiologist. This step is complte.

c) The mounted uncompressed samples were imaged at Brookhaven National Laboratory as well as in the compressed states. This step is complete.

d) The samples were returned to UNC in their compressed state using a General Electric digital mammography system. This step is complete.

Task 3:

a) The image format of the equipment used at Brookhaven National Laboratory was converted to a format that can be used on the equipment at UNC. This step is complete.

b) Images were cropped into single image files. This step is complete.

c) The image pairs were registered, but it was found that minor shifts during the acquisition phase caused a significant loss of image quality in the DEI apparent absorption and refraction images. Tests were performed to see if the problem could be corrected, but the size of the tissues used in the study makes putting multiple images on the same imaging plate impossible. Since the plate must be moved for each DEI image, it is impossible to perfectly align the image plate. The necessary data for the study can be obtained from the +½ Darwin Width, -1/2 Darwin Width, and peak positions on the rocking curve combined with the radiograph. This is minor alteration to what was presented in the proposal, but we do not believe that this change will significantly affect the outcome of the study. From experience gained in this study, the only way to effectively register the images is to cut the tissues into much smaller regions of interest. For this type of study, it is necessary to preserve as much as the tissue as possible. This task is complete.

d) An image viewer has been created for presentation of the images. In addition to softcopy presentation of the images, readers will also have hardcopy radiographs of the compressed tissue specimens. The reader will be able to manually change the intensity window of the presented image, and a magnifying glass will be provided. This task is complete.

e) All images have been processed. This task is complete.

f) A small pilot study was developed using one radiologist. This task is complete.

g) A pilot study was performed, but it was determined that histology would have to be provided to accurately assess the images. Correlation with pathology was not specifically stated in the proposal or statement of work, but experience has shown this to be a necessary addition. We are paying for this costly step out of laboratory funds and not out of funds allocated in this grant. The addition of this step has delayed running the reader study, and this step is currently in progress.

Task 4:

a) Radiologists are being recruited for the study, this step is in progress.

b) Readers will be trained once selected, this step has not yet begun.

c) The reader study will begin as soon as the pathology results return. Expected start date for the reader studies is February 2005. This step has not yet begun.

Task 5:

The statistical design of the study has been determined, but analysis has not yet begun. The step will occur at the conclusion of the reader studies.

Task 6:

Manuscript preparation has not yet begun.

Key Research Accomplishments:

- Obtained specimens for study
- Created compression/immobilization holders
- Imaged uncompressed tissues at UNC Hospitals
- Imaged uncompressed and compressed tissues at Brookhaven National Laboratory
- Imaged compressed tissues at UNC Hospitals
- Converted, copped, and processed all images for study
- Developed an image viewer for presentation
- Developed and performed pilot study
- Sent tissues for pathology correlation

Reportable Outcomes:

Funding and research for from this study is being used toward the completion of my PhD in Biomedical Engineering. This study is a component of my doctoral research.

Conclusions:

Conclusions pending completion of the reader study.

References:

[1] E.D. Pisano, R.E. Johnson, D. Chapman, J. Geradts, M.V. Iacocca, C.A. Livasy, D.B. Washburn, D.E. Sayers, Z. Zhong, M.Z. Kiss, and W.C. Thomlinson, "Human Breast Cancer Specimens: Diffraction Enhanced Imaging with Histologic Correlation-Improved Conspicuity of Lesion Detail Compared to Digital Radiography", Radiology **214**, 895-901 (2000).

[2] Z. Zhong, W. Thomlinson, D. Chapman, and D. Sayers, "Implementation of diffraction-enhanced imaging eperiments: at the NSLS and APS", Nucl. Instrum. Methods Phys. Res. A **450**, 556-567 (2000).